



NOTE

Internal Medicine

A clinical case of single left ventricle in a Holstein calf

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ABSTRACT. A 15-day-old Holstein calf with lethargy and tachypnea presented to the Veterinary Teaching Hospital at Obihiro University of Agriculture and Veterinary Medicine for evaluation of suspected congenital heart defect. A Levine grade 6 systolic murmur was noted at right apical site auscultation and phonocardiogram also recorded systolic a murmur. Electrocardiography findings include increased R and S waves, R wave split, and negative T waves without arrhythmia. Echocardiography revealed a single ventricle with a trace of the right ventricular wall, atrioventricular valve regurgitation, and turbulent in a single ventricle. Arterial blood analysis showed a marked decrease in oxygen saturation of 78% and oxygen partial pressure of 44 mmHg. Post-mortem examination confirmed the diagnosis of a single left ventricle.

KEY WORDS: clinical findings, Holstein calf, single ventricle

A single ventricle is a rare cardiac malformation [1]. In the human medicine, single ventricle abnormalities are divided into three types—left single ventricle in which a trace of the right ventricle is observed, a right single ventricle in which a trace of left ventricle is observed, and an undefined single ventricle in which no trace ventricle exists [1]. Given its rarity in cattle, most case reports on this condition describe the pathomorphological findings in necropsy [2, 6–8]. Only a few reports with clinical findings are available [5]. Here we describe the clinical data of a Holstein-Friesian calf with a single left ventricle, including physical examination, echocardiography, electrocardiography, blood gas analysis and autopsy findings.

A 15-day-old Holstein-Friesian calf presented to the Veterinary Teaching Hospital at Obihiro University of Agriculture and Veterinary Medicine from a local veterinarian for evaluation of suspected congenital heart defect by the findings of depression, tachypnea, and exercise intolerance. The initial physical examination revealed a temperature of 40.3°C, heart rate of 180 beats per minute, and respiratory rate of 76 breaths per minute. Abdominal forced breathing was observed, but there was no cyanosis in the visible mucous membrane, and the oral cavity and extremities were warm. The calf drank milk slowly, at less than 1.8 l at a time. On thoracic auscultation, a Levine grade 6 right-sided apical systolic murmur was noted. The systolic murmur was also confirmed in the phonocardiography analysis (Fig. 1). Waveform abnormalities, including increased amplitude of R and S waves, R wave split, and negative T waves were recorded in electrocardiography (Fig. 1). Arrhythmia was not recorded. A complete blood count showed no abnormal values, but arterial blood analysis revealed a marked decrease in oxygen saturation of 78% and oxygen partial pressure of 44 mmHg.

The ventricular septum could not be identified by echocardiogram. The tricuspid and mitral valves opened in one dilated ventricle, and a pocket-like structure was observed on the right ventricle wall (Fig. 2). Blood flow was not confirmed in this pocket-like structure. Furthermore, atrioventricular valve regurgitation was observed during systole (Fig. 3A), and mosaic-pattern was observed in a ventricle during diastole (Fig. 3B).

The present case was judged to be a poor prognosis, and autopsy was performed after euthanized by arterial exsanguination under deep anesthesia with xylazine and thiamylal sodium at 19 days of age (Animal experiment approval No. 29–38, Obihiro University of Agriculture and Veterinary Medicine). The outer shape of the heart was expanded (Fig. 4). Left atrium was also enlarged (Fig. 4). A two-dimensional schematic picture of the heart is shown in Fig. 5. A single ventricle was observed without the presence of the ventricular septum. A pocket-like cavity was observed in the free wall on the right side of the heart (Figs. 6 and 7). Both left and right atrium were enlarged. The left atrium and mitral valve, as well as the right atrium and tricuspid valve, were normally positioned. Both the pulmonary trunk and the aorta began from the huge single ventricle and showed no stenosis or valve abnormalities and were not dislocated (Fig. 7). The paraconal interventricular groove (Fig. 4) and the inner edge of the pocket-like cavity on the right free wall

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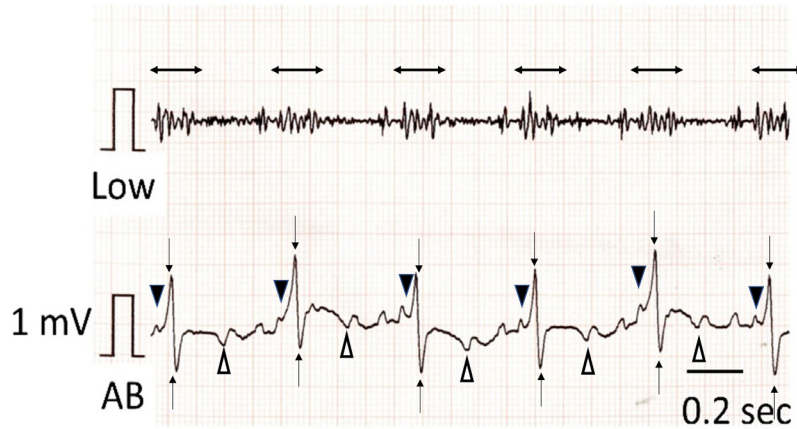


Fig. 1. Systolic murmur was recorded at the left-sided apical in the phonocardiography analysis (double arrows). Waveform abnormalities, including increased amplitude of R and S waves (arrows), R wave split (arrow heads), and negative T waves (white arrow heads) were recorded in electrocardiography. Low: phonocardiography with a low pass filter, AB: A–B lead.

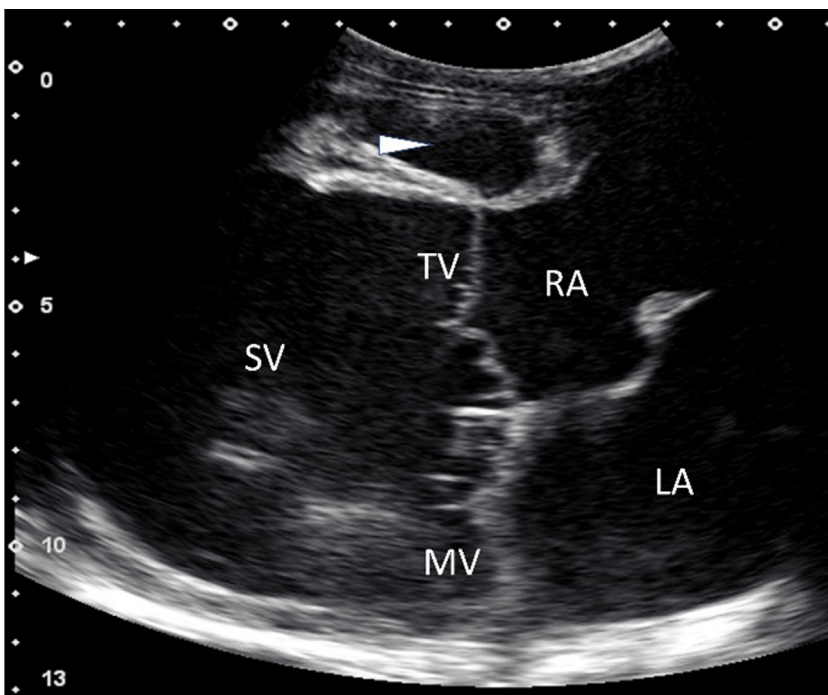


Fig. 2. Echocardiography. Right long-axis cross-sectional image shows the tricuspid valve (TV) and mitral valve (MV) opening in a single ventricle (SV); the ventricular septum is absent. A pocket-like structure (white arrowhead) was recorded on the right side of the heart. RA: right atrium, LA: left atrium.

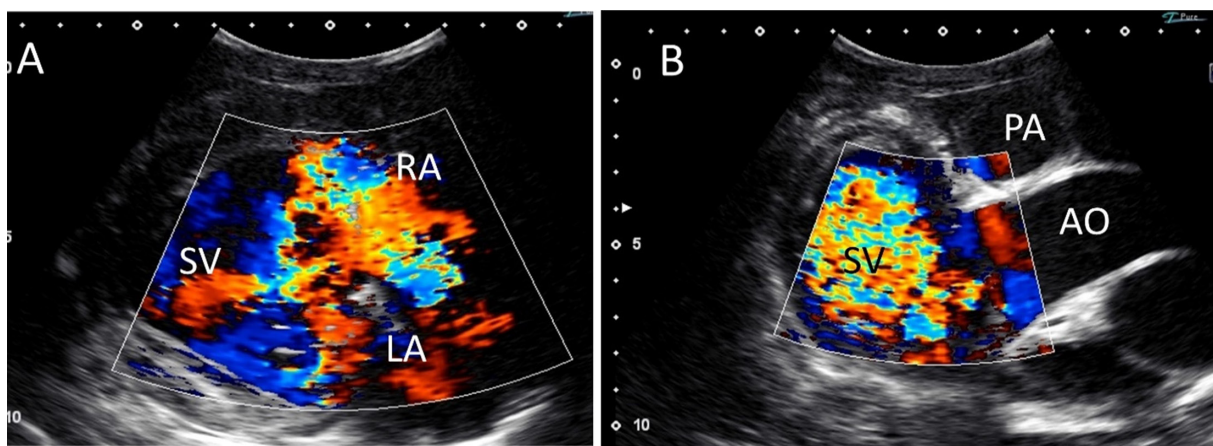


Fig. 3. Echocardiography. Right major axis cross-sectional image revealed tricuspid regurgitation during systole. SV: single ventricle, RA: right atrium, LA: left atrium. (B) mosaic pattern was observed in the SV during diastole. PA: pulmonary artery, AO: aorta.

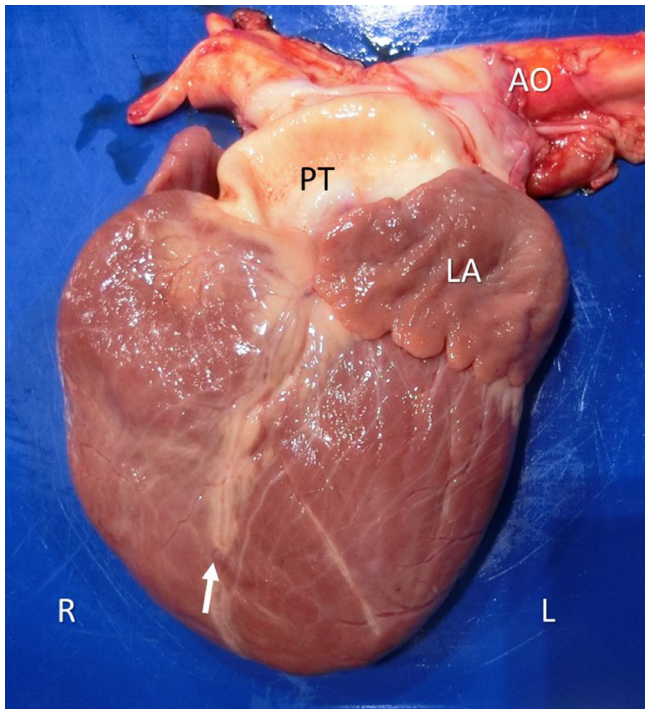


Fig. 4. The outer shape of the heart from left side. The heart expanded bluntly and left atrium (LA) was also enlarged. The arrow shows paraconal interventricular groove. PT: pulmonary trunk, AO: aorta, L and R: left and right side of the heart, respectively.

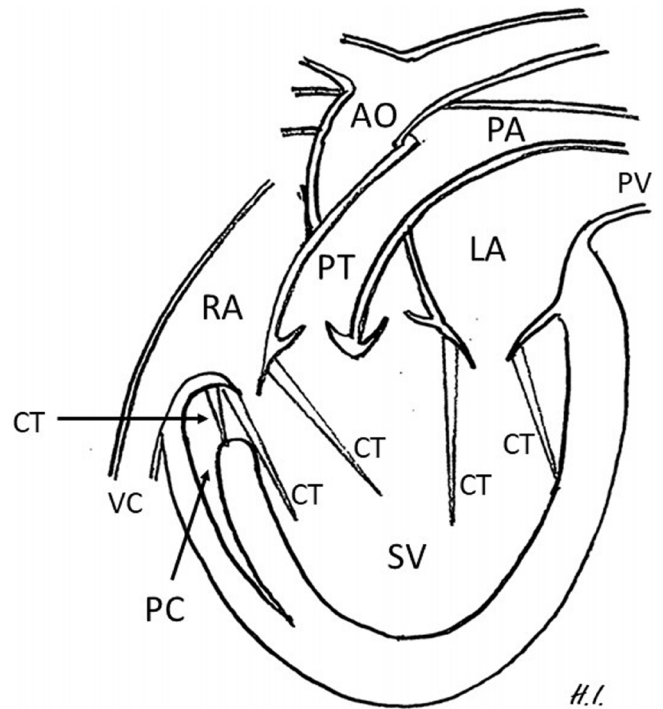


Fig. 5. A two-dimensional schematic picture of the heart. The atrio-ventricular opening was completely separated. Both tricuspid and mitral valves opened in the single ventricle (SV). LA: left atrial, RA: right atrial, PT: pulmonary trunk, PA: pulmonary aorta, AO: aorta, CT: chordae tendineae, PV: pulmonary vein, VC: vena cava, PC: pocket-like cavity.

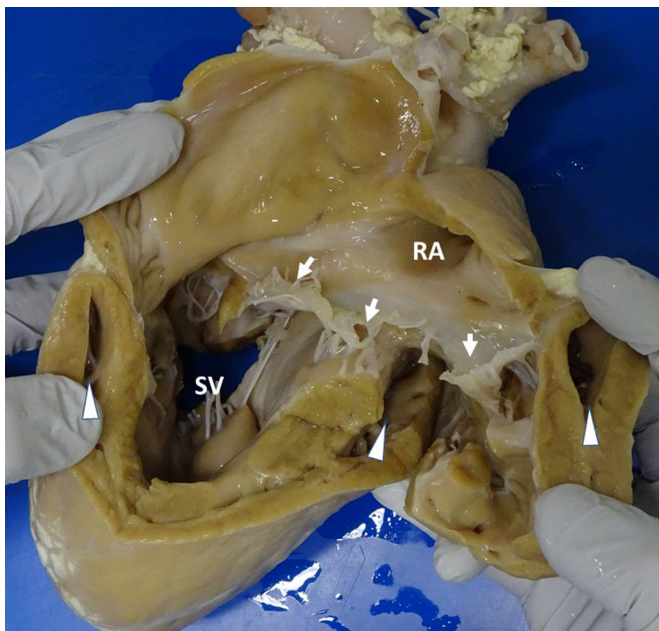


Fig. 6. When the ventricle was incised from the right side, a pocket-like cavity was found in the free wall on the right side of the heart (white arrowheads). The chordae tendineae of the tricuspid valves (white arrows) were terminated at the ventricular wall and the papillary muscle. SV: single ventricle, RA: right atrial.

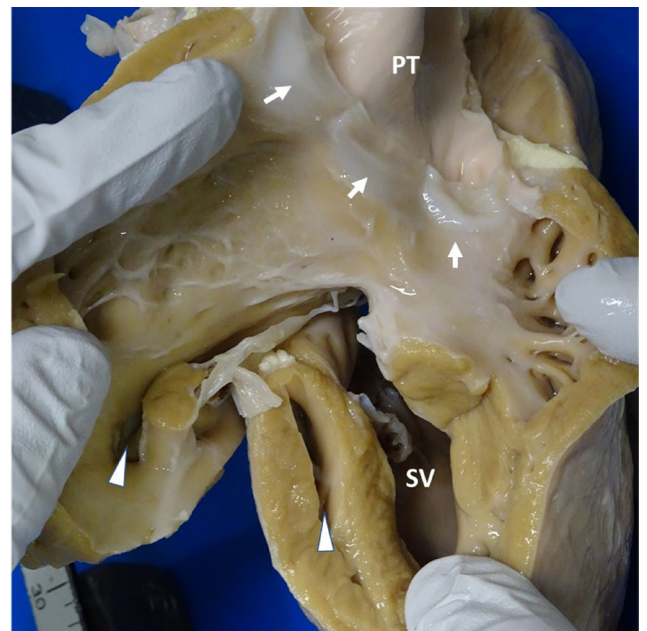


Fig. 7. When the ventricle was incised from the pulmonary trunk (PT), it originated from the single ventricle (SV) and showed no stenosis or valve abnormalities (white arrows). A pocket-like cavity was found in the free wall on the right side of the heart (white arrowheads).

of the heart did not correspond. The atrioventricular opening was completely separated, and the size of the opening was larger on the right side. The chordae tendineae of the left and right atrioventricular valves were terminated at the ventricular wall and the papillary muscle. The pocket-like cavity (trace of right ventricle) of the free wall on the right side of the heart was located just below the tricuspid valve and behind the trabeculae carneae and was connected with the single ventricle.

Histological findings of the lungs include lobule exhibiting atelectasis, but no significant inflammatory cell infiltration was observed, suggesting atelectasis. No findings suggestive of pulmonary edema were found. In addition, although mild hyperplasia of fibrous connective tissue was observed around the vascular wall of the lung, plexiform lesions as observed in typical pulmonary hypertension were not formed.

In the present case, autopsy revealed a pocket-like cavity in the free wall of the right side, which was considered a trace of the right ventricle. The diagnosis of left single ventricle was made on this basis. A single ventricle is a very rare congenital cardiac malformation in cattle, but most single ventricle cases in cattle reported in the past were left single ventricles [8]. Although concurrent congenital malformations with a single ventricle have been reported, such as stenosis and dislocation of the aorta and pulmonary artery, atrial septal defect, patent ductus arteriosus, and aortic arch anomalies [2, 6–8], there were no concurrent abnormalities in the present case.

In single ventricle cases, arterial blood and venous blood intermingle in one ventricle, resulting in the circulation of extremely hypoxic arterial blood throughout the body, which typically leads to clinical symptoms of heart failure and arrhythmias [2, 5]. In addition to respiratory distress, exercise intolerance and depression were observed in the present case. Arterial blood gas analysis confirmed marked hypoxia compared with the reference range [4]. A hemoglobin concentration of 12.4 g/dl seems to be sufficient for blood gas tests. Arterial blood had low oxygen saturation and was intolerant to exercise. The reason for the absence of cyanosis is unknown. Pulmonary edema could not be confirmed as the cause of tachypnea and tachycardia in this case, suggesting the possibility of respiratory activation due to fever (40.3°C) or hypoxemia.

The combination of phonocardiograph with electrocardiogram analysis confirmed systolic murmur in the present case. Considering the location and timing of turbulence noted by echocardiography, the systolic murmur can be due to atrioventricular valve regurgitation due to diastole of single ventricle. Significant dilation of the left atrium suggests mitral regurgitation or mitral stenosis. However, since the echo findings showed that tricuspid regurgitation was the main cause and mitral regurgitation was slight, the possibility of congenital left atrial dilatation cannot be ruled out. Electrocardiographic abnormalities, including increased R and S waves and negative T waves, were considered to reflect dilation of the entire heart. R wave split might suggest the bundle block in the small trace right ventricle.

A single ventricle can be diagnosed relatively easily by echocardiography [2]. In the present case, a single ventricle was also strongly suspected at the antemortem examination because echocardiography revealed that both tricuspid and mitral valves were opened in one dilated ventricle, and the normal ventricular septum was not observed. In addition, since a pocket-like structure was confirmed on the right side of the heart, a left single ventricle with a trace right ventricle was predicted. In the human medicine, single ventricle cases are often treated by cardiac surgery, but the prognosis is not always enough [3, 8]. In the case of farm animals, single ventricle cases can be diagnosed prenatally by clinical findings and echocardiography, but the prognosis is typically poor. In conclusion, this is the first detailed report of clinical findings for single ventricle in a Holstein calf.

CONFLICT OF INTEREST. The authors declare that there are no conflicts of interest.

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